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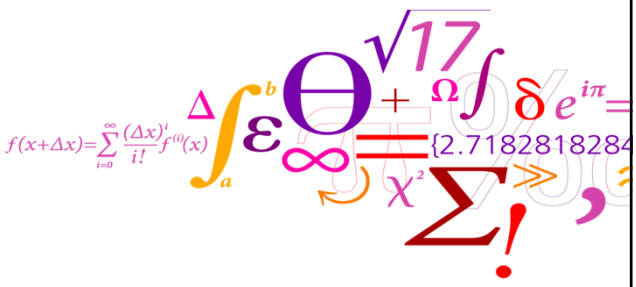
Test og karakteristik af LED-lyskilder og lamper

Carsten Dam-Hansen, DTU Fotonik



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Indhold

- LED og SSL status, hvorfor er test nødvendigt?
- Ny LED test standard
- Virker den nye standard?
  - International laboratorie sammenligning
- Quality lab, forsknings og kommercielt fotometri
  - Intergrerende kugle faciliteter
  - Goniofotometer facilitet
- Levetid: lumen og color maintenace
- Laboratorie rundvisning

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Status, LED enheder

LED enheder

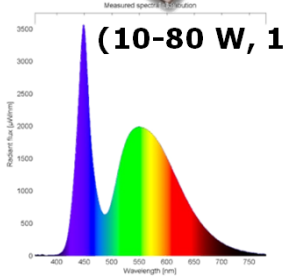
3 mm

(~ 1-5 W, -400 lm)

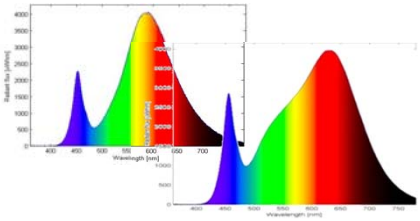
(10-80 W, 1500-6000 lm)

Farvetemperatur

2200 - 3500 K **> 5000 K**



Effektivitet:
123 lm @ 350 mA ~ 117 lm/W



160 lm @ 350 mA ~ 152 lm/W (@ 25 °C)
139 lm @ 350 mA ~ 132 lm/W (@ 85 °C)

Laboratorie resultater: 303 lm/W

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Status, SSL produkter

SSL produkter er baseret på LED enheder
inkluderer optik, køleprofil og elektronik

Retrofit produkter

60-120 lm/W

LED armaturer

~ 90-130 lm/W

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International/europæisk Test Standard

Der er en international og en europæisk test standard for SSL produkter udgivet i år og udarbejdet i samarbejde imellem:

CIE TC2-71, Chair, Yoshi Ohno (US)
CEN TC169 WG7, Chair, Guy Vandermeersch (BE)

CIE S 025/E:2015 Test Method for LED Lamps, LED Luminaires and LED Modules

EN 13032 Lighting Applications — Measurement and presentation of photometric data of lamps and luminaires — Part 4: LED lamps, modules and luminaires

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International/europæisk Test Standard

Absolut fotometri, lamper og armaturer måles I forhold til en kalibreret standard lamp (halogen)

Test procedure,

- **Ingen indbrænding**
- **Termisk stabilisering 0.5 % variation i lysstrøm og effekt**
- **Omgivelses temperatur 25°C ± 1.2°C**
- **Integrerende kugle (2π og 4π setup) med spektroradiometer, eller med fotometer**
- **Goniofotometer med fotometer og/or spektroradiometer**

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International/europæisk Test Standard

	Acceptance interval*1 (WD2)	Instrument uncertainty (k=2) (WD2)	Tolerance Interval *2 (WD3)
Ambient temperature	± 1 °C	≤ 0.2 °C	± 1.2 °C
Surface temperature (LED module)	± 2 °C	≤ 0.5 °C	± 2.5 °Ç
Air movemet speed	± 0.2 m/s	≤ 0.05 m/s	± 0.25 m/s
Supply voltage (AC)	± 0.2 %	≤ 0.2 %	± 0.4 %
(DC)	± 0.1 %	≤ 0.1 %	± 0.2 %

*1 called "tolerance interval" in WD2
*2 no requirement of instrument uncertainty in WD3

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International/europæisk Test Standard Parametre

Fotometrisk:
- **Luminous flux [lm]**
- **Partial Luminous flux [lm]**
- **Efficacy [lm/W]**
- **Luminous intensity distribution [cd]**

Electrisk:
- **Power [W]**
- **Current [A]**
- **Power factor**

Kolorimetrisk:
- **Correlated color temperature [K], Duv**
- **Color rendering index**
- **Color coordinates**

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Usikkerhed

Resultatet af målinger skal angives med usikkerhed (evt. for produkt type)

Φ = 834 lm ± 4 %

CCT = 3120 K ± 61 K x = 0.3543 ± 0.0035

CCT = 6540 K ± 255 K y = 0.5443 ± 0.0050

Udvidet usikkerhed k=2 svarende til at den rigtige værdi med 95 % sikkerhed ligger indenfor det angivne interval

Total flux vil således være i intervallet: [801 lm – 867 lm]

Det er svært for testlaboratorier at udføre usikkerhedsberegninger, især for kolorimetriske parametre. Teknisk note fra CIE er under udarbejdelse.

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IC2013 world's largest interlaboratory comparison on SSL

- **Undersøge robusthed af SSL test metode igennem international laboratory comparison (IC2013)**
- **Midlertidig SSL test metode der benytter de strengeste krav og tolerancer således at alle opfyldes:**
  - **LM-79-08 IESNA**
  - **CEN/CIE Test method draft**
  - **IEC 62722 (LED luminaire) IEC 62612 (LED lamp) Annex A**
  - **JIS 7801, 8105-5 (Japan)**
- **5-6 forskellige typer af LED lamps**
- **Måle Protokol**
- **PPR og IR er givet til deltagende laboratorier**
- **Som færdighedstest ISO/IEC 17043**
- **Slutrapport er udgivet i går http://ssl.iea-4e.org/**
- **Generelt god overensstemmelse flux ± 4 %, kromaticitet ± 0.004**
- **Vist at metoden er god undtagen for strømmålinger**

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IC2013 world's largest interlaboratory comparison on SSL

23 laboratorier har gennem-ført IC2013 i Europa under VSL,
I Danmark har DTU Fotonik og Delta deltaget.

	Country	Laboratories	Nucleus Lab
Europe	FRANCE	6	VSL
	Netherlands	4	VSL
	Sweden	3	VSL/NLTC
	Denmark	2	VSL
	Germany	2	VSL
	United Kingdom	2	VSL
	Belgium	1	VSL
	Finland	1	VSL
	Russia	1	VSL
Aasia/ Pacific	Japan	12	AIST,NMIJ
	China	5	NLTC
	Korea	5	VSL
	Taiwan	4	NLTC
	Australia	3	NLTC
	New Zealand	1	NLTC
Americas	Canada	1	NIST
	Brazil	1	NIST
	Total	54	

Nucleus Lab	laboratories
AIST, NMIJ	12
NIST	2
NLTC	14
VSL	26
Total	**54**

NIST MAP NVLAP linked labs	45
APLAC PT linked labs	21
Grand total	**110**

Nucleus Labs	4
Total number of labs	114
Repeated testing	3
Total number of data entry For final report	123

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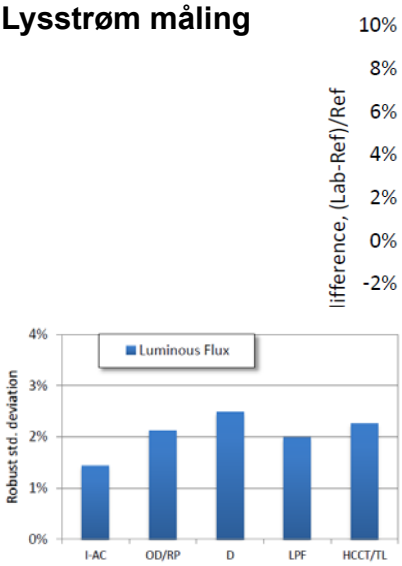
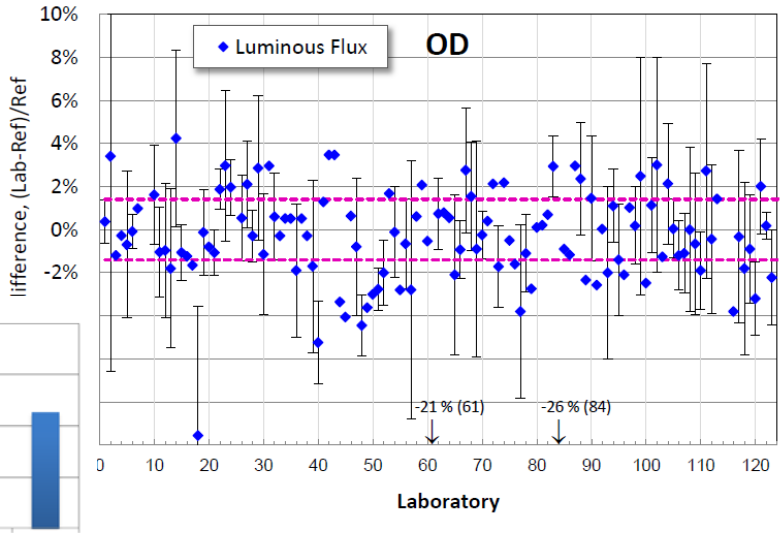
Lysstrøm måling





9-2. Relative differences of total luminous flux for omnidirectional LED lamp (OD)

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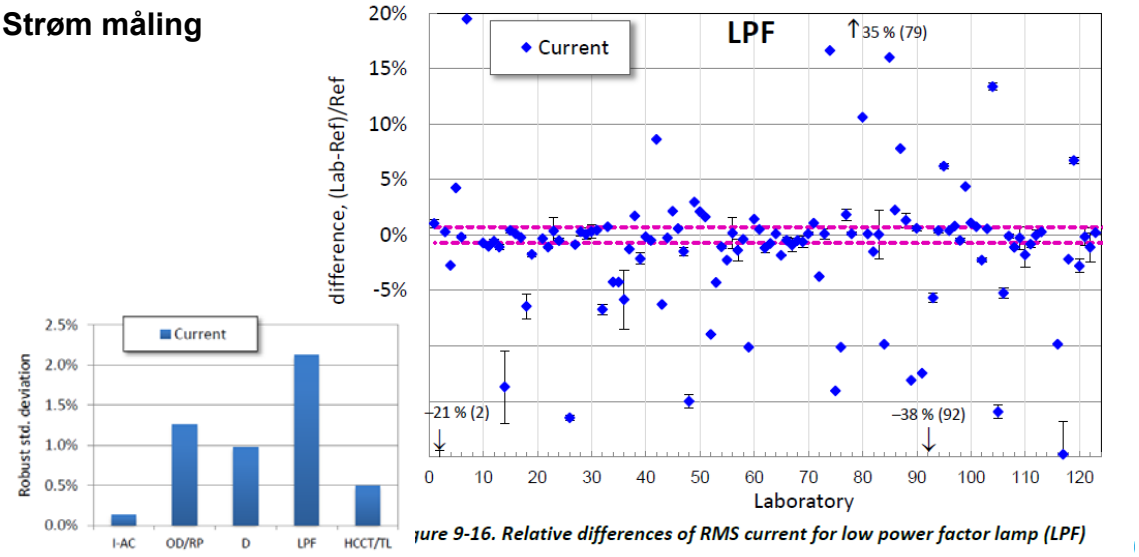
Strøm måling



ure 9-16. Relative differences of RMS current for low power factor lamp (LPF)

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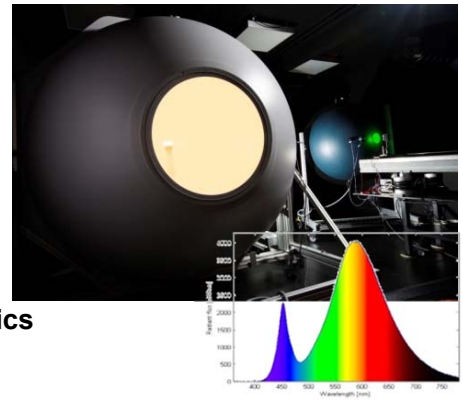
Integrating sphere lab

Total spektral flux målinger i total flux (4π) og i forward flux (2π) konfiguration:



1m og 2m diameter kugler, med 15 og 60 cm port

Til måling af
- **Total spectral power distribution**
- **Luminous flux [lm]**
- **Efficiency [lm/W]**
- **Correlated Color temperature, Duv**
- **Color rendering index, other color rendering metrics**

Bølgelængde område:
Array spektrometer, 360-830 nm
Dobbel monokromator, 250-1700 nm, (UV og blue light hazard)

LED komponenter under strøm og temperatur kontrol

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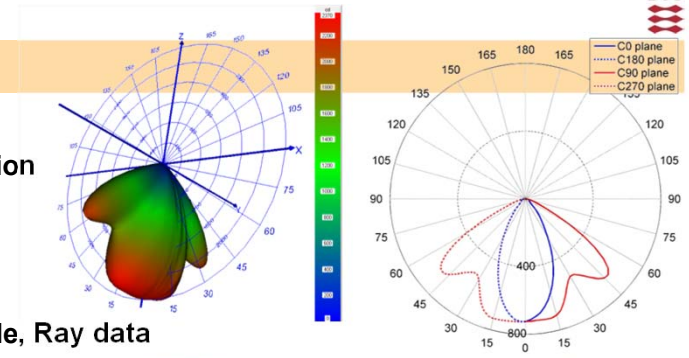
Goniofotometer lab



Nærfelts goniofotometer
Lamper med 2m i største dimension

måling af vinkel fordeling af

- **Intensitet (LID),**
  ies-file eller eulumdat file, Ray data
- **Kromaticitet**
- **Spectral power distribution,**
- **Correlated Color temperature, Duv**
- **Color rendering index**

og
- **Lysstrøm [lm]**
- **Effekt [W]**
- **Effektivitet [lm/W]**

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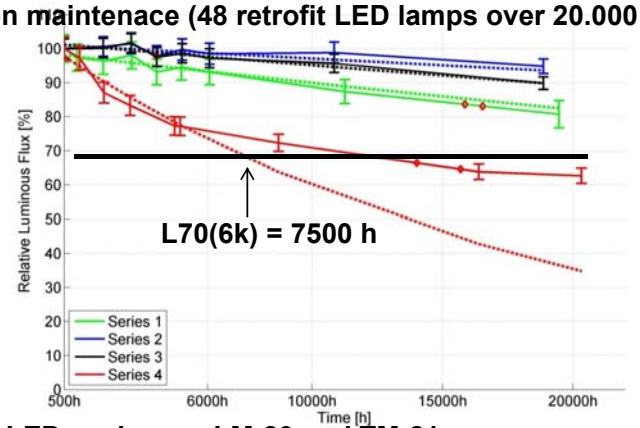
Luminous flux maintenance

LED fejler ikke pludseligt, men degraderer langsomt – også efter at have nået brugbar lysstrøm
Langtids målinger af lumen maintenace (48 retrofit LED lamps over 20.000 h)



Etableret IES standard for LED packages: LM-80 and TM-21
Ny IES standards for LED lamps: LM-84-14 and TM-28-14
Behov for accelerated test methods, med on/off cycling

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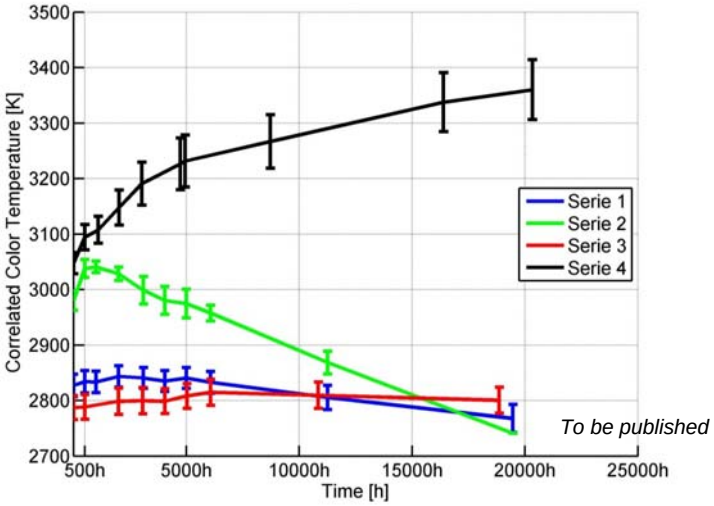
Color maintenance

Correlated color temperature som funktion af tid:



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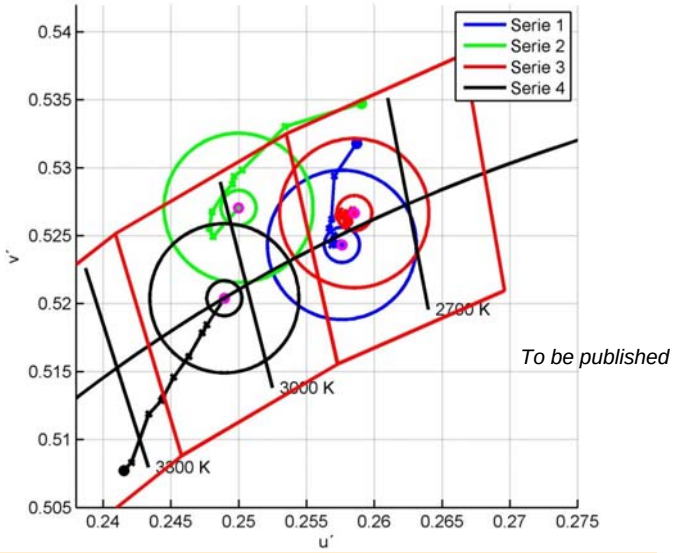
Color maintenance

Farve skift selvom CCT er konstant, chromaticity coordinates som funktion af tid:



To be published

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Tak for opmærksomheden

I laboratoriet får I mulighed for at se og stille flere spørgsmål

Eller kan jeg kontaktes på

cadh@fotonik.dtu.dk